

The invention claimed is:

1. A recirculation system for retaining substantial thermal energy content of air drawn from within a confined environment as part of an exhaust flow which includes gaseous contaminants, comprising:

5 a collector device located within the confined environment to receive and establish the exhaust flow of contaminants and air from within the confined environment;

a cleaner device connected to receive the exhaust flow from the exhaust collector device;

10 the cleaner device comprising a scrubber module, a liquid removal module and a filtering and conversion module connected in series through which the exhaust flow passes;

the scrubber module including flow passageways through which the exhaust flow passes and into which cleaning liquid is distributed for mixture with and entrainment of contaminants of the exhaust flow;

15 the liquid removal module removing cleaning liquid from the flow from the scrubber module;

the filtering and conversion module comprising an odor-removing filter and a catalyst;

20 the odor-removing filter removing odor from the flow from the liquid removal module;

the catalyst facilitating conversion of the gaseous contaminants gas in the flow from the liquid removal module into benign gaseous constituents; and

25 a delivery device located within the confined environment to receive the flow from the cleaner device and discharge the flow into the confined environment.

2. A recirculation system as defined in claim 1 wherein the confined environment is a food preparation establishment having an open flame cooker which produces carbon monoxide gas, odor, smoke and airborne grease as particulate and gaseous cooking exhaust contaminants, and wherein:

- 5                   the collection device comprises an exhaust collection hood located  
over the open flame cooker;
- the scrubber module remove substantially all of the particulate  
contaminants from the exhaust flow; and
- a catalyst facilitates conversion of the carbon monoxide gas in the  
10 flow from the liquid removal module into carbon dioxide gas.
3.       A recirculation system as defined in claim 2 wherein:  
          the delivery device discharges the flow from the filtering and  
conversion module into the exhaust hood.
4.       A recirculation system as defined in claim 1 wherein the  
contaminants of the exhaust flow include carbon monoxide gas, and wherein:  
          the catalyst operates at room temperature to oxidize the carbon  
monoxide into the carbon dioxide.
5.       A recirculation system as defined in claim 4 wherein:  
          the catalyst utilizes air from the exhaust flow and carbon monoxide  
from the flow to form carbon dioxide.
6.       A recirculation system as defined in claim 4 wherein:  
          the catalyst comprises mixed manganese copper oxide.
7.       A recirculation system as defined in claim 4 wherein:  
          the catalyst comprises potassium permanganate.
8.       A recirculation system as defined in claim 4 wherein the  
contaminants from the exhaust flow include odor, and wherein:  
          the filter comprises a carbon particle filter.
9.       A recirculation system as defined in claim 4 further comprising:  
          a heater positioned to heat the catalyst to a predetermined  
temperature sufficient to regenerate catalytic characteristics of the catalyst.
10.      A recirculation system as defined in claim 4 wherein the filtering and  
conversion module includes a catalyst cell through which the flow from the liquid  
removal module passes, the catalyst cell comprising:  
          a layer of particles of the room-temperature catalyst; and  
5           a layer of carbon particles.

11. A recirculation system as defined in claim 10 wherein the catalyst cell further comprises:

5 a heater positioned within the layer of catalyst particles to heat the catalyst particles to a predetermined temperature sufficient to regenerate catalytic characteristics of the catalyst.

12. A recirculation system as defined in claim 4 wherein the filtering and conversion module further comprises:

a filter device connected to receive the flow from the liquid removal device, the filter device comprising one of a HEPA, DOP or BAG filter.

13. A recirculation system as defined in claim 1 wherein the scrubber module further comprises:

5 a baffle-defining structure comprising a plurality of vertically spaced and interdigitated deflection plates which define a serpentine-shaped flow passageway through which the exhaust flow moves generally upward; and

a liquid distributor positioned within each passageway of the baffle-defining structure to flow liquid cleaning agent downward through each passageway and generally onto the deflection plates;

10 the baffle-defining structure further comprising a plurality of vertically spaced deflection plates extending generally horizontally in the passageway, each deflection plate having a main portion sloping downward and an outer end lip portion extending from the main portion, vertically adjacent and consecutive deflection plates in the passageway extending in opposite directions with respect to one another, the vertically spaced deflection plates interdigitating with one another, and the lip portions horizontally overlapping the main portion of at least  
15 one vertically adjacent deflection plate to form the passageway in a serpentine manner having repeated alternating-direction turns around the lip portions of the deflection plates;

20 the liquid flows off the lip portion of each deflection plate into and through the exhaust flow turning around the lip portion to mix the exhaust flow and the liquid to entrain the contaminants in the liquid.

14. A recirculation system as defined in claim 13 wherein:

the vertically adjacent deflection plates overlap one another within the range of approximately 51% to 80% of the horizontal extent of each deflection plate.

15. A recirculation system as defined in claim 13 wherein:

the angle of each lip portion relative to the flow around each lip portion causes at least a portion of the liquid flowing from the lip portion of the deflection plate to be driven upward from the lip portion with the flow and mixed  
5 with the flow.

16. A recirculation system as defined in claim 13 wherein:

the main portion of the immediately below-positioned deflection plate and the immediately above-positioned deflection plate define a flow/liquid mixing zone in the passageway between vertically adjacent deflection plates;

5 the angle of each lip portion relative to the flow around each lip portion causes at least a portion of the liquid flowing from the lip portion of the deflection plate to be driven upward from the lip portion with the flow and mixed with the flow in the mixing zone; and

10 the lip portion of each deflection plate extends into the flow to create a vortex motion of the flow in the mixing zone to increase the contact of the contaminants in the flow with the liquid.

17. A recirculation system as defined in claim 13 wherein the scrubber module further comprises further comprises:

a liquid removal device connected to receive the flow from the baffle-defining structure, the flow from the baffle-defining structure containing a mist of  
5 the liquid, the liquid removal device removing a substantial majority of the liquid mist from the flow before passing into the liquid removal module.

18. A recirculation system as defined in claim 17 wherein the liquid removal device comprises a cyclone.

19. A recirculation system as defined in claim 1 wherein the liquid removal device comprises:

a curved sidewall structure along which the flow from the scrubber module moves in a curved motion to force liquid in the flow from the scrubber module to coalesce into liquid and drain along the sidewall structure.

20. A recirculation system as defined in claim 19 wherein contaminants in the flow are also forced against the sidewall structure to become entrained in the liquid on the sidewall structure.

21. A recirculation system as defined in claim 19 further comprising a demisting wall positioned in the flow between the scrubber module and the liquid removal module to remove a part of the liquid mist in the flow from the scrubber module.

22. A recirculation system for retaining substantial thermal energy content of air drawn from within a confined environment as part of an exhaust flow which includes gaseous contaminants, comprising:

a collector device located within the confined environment to receive and establish the exhaust flow of contaminants and air from within the confined environment;

a scrubber module comprising a passageway through which the exhaust flow from the delivery device moves in one direction and a liquid cleaning agent moves in an opposite direction by which to entrain contaminants from the exhaust flow within the liquid;

a liquid removal module comprising a curved sidewall structure along which the flow from the scrubber module moves in a curved motion to force liquid in the flow to coalesce on the sidewall structure and to force contaminants in the flow against the sidewall structure to become entrained in the liquid on the sidewall structure;

a filtering and conversion module comprising an odor-removing filter and a catalyst;

the odor-removing filter removing odor from the flow from the liquid removal module;

the catalyst facilitating conversion of the gaseous contaminants in the flow from the liquid removal module into benign gaseous constituents; and

a delivery device located within the confined environment to receive the flow from the cleaner device and discharge the flow into the confined environment.